

MICROANALYSIS OF PLATINUM GROUP ELEMENTS IN IRON METEORITES USING LASER ABLATION ICP-MS. A. J. Campbell and M. Humayun, Department of the Geophysical Sciences, The University of Chicago, 5734 S. Ellis Ave., Chicago, IL 60637 (acampbel@midway.uchicago.edu).

Introduction: Laser ablation ICP mass spectrometry was used to measure the concentration of the platinum group elements (PGEs: Ru, Rh, Pd, Os, Ir, and Pt), Re, and Au in 17 iron meteorites on a spatial scale of <20 μm . The distribution of PGEs, Re, and Au between metallic phases in these meteorites, and the bulk compositions of these irons are reported below.

Experimental: A CETAC LSX-200 laser ablation peripheral was used for solid sample introduction into a magnetic sector ICP mass spectrometer, the Finnigan MAT Element [1]. The LSX-200 utilizes a 266 nm laser with pulse length 6 ns, pulse energy 0.1-4.0 mJ, and repetition rate 1 - 20 Hz. The ablated material was carried by Ar gas to the ICP assembly of the Element. The washout time of the signal is 5 s per order of magnitude decrease in signal intensity. The Element was operated in low resolution ($R = 340$) mode; a gas blank and elemental interferences were stripped from the signal and polyatomic interferences were determined to be negligible for the isotopes monitored (^{57}Fe , ^{59}Co , ^{61}Ni , ^{101}Ru , ^{103}Rh , ^{105}Pd , ^{187}Re , ^{192}Os , ^{193}Ir , ^{195}Pt , ^{197}Au). The entire mass range was scanned at a rate of once per 0.5-1.0 s during data collection. Instrumental sensitivity factors for each isotope were determined by measuring signal intensity from the group IVB ataxite Hoba, whose PGE concentrations were determined independently using isotope dilution ICP-MS (with internal standardization for Rh). After correcting each signal for its instrumental sensitivity, concentrations were obtained by normalization to 100 wt% (dominated by Fe, Ni, and Co). Line scan analyses were performed by translating the sample under the laser beam at a rate of 5 $\mu\text{m/s}$; the resulting signal could either be integrated for a bulk composition over the region scanned, or analyzed as a time series to document spatial heterogeneities in the sample.

Isotope dilution ICP-MS was used to determine bulk PGE concentrations in seven meteorites including Hoba, the laser ablation ICP-MS standard. Aliquots of 0.25-6.0 mg were spiked with ^{99}Ru , ^{110}Pd , ^{185}Re , ^{190}Os , ^{191}Ir , ^{198}Pt and then dissolved in 2 ml of $\text{HCl}+\text{HNO}_3$ in glass carius tubes or in teflon digestion vessels. These solutions were introduced to the Element using a CETAC MCN-6000 desolvating nebulizer that provides a sensitivity of 10^6 cps for a 1 ppb ^{115}In solution. The procedural blanks were 100-250 fg/g, except 6 fg/g for Ir and 4 pg/g for Re.

Results and Discussion: Isotope dilution ICP-MS data for Hoba IVB and Filomena IIA are presented in Figure 1. The new data compare well with results from [2, 3], and the Hoba data obtained with this method were used to standardize the laser ablation ICP-MS analyses.

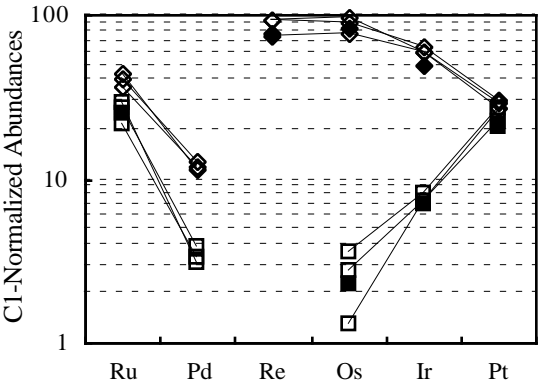


Figure 1. Triplicate ID-ICP-MS analyses of Hoba and Filomena. Diamonds: Hoba; squares: Filomena; filled symbols: literature data [2, 3].

Table 1. LA-ICPMS Analysis of Filomena.

	Hoba	Filomena	error	Lit. value	stdev
Ru	28.61	15.20	0.80	17.95	0.97
Rh	4.86	2.86	0.13		
Pd	6.65	1.72	0.15		
Re	3.15	0.20	0.04	0.24	0.02
Os	42.48	1.09	0.08	1.09	0.11
Ir	29.14	3.22	0.21	3.37	0.06
Pt	28.60	21.28	1.20	20.35	0.49
Au	0.08	0.60	0.03	0.61	0.01

Filomena is a group IIA hexahedrite that exhibits high homogeneity, and for this reason it is frequently analyzed as a secondary standard [e.g., 2]. A laser ablation ICP-MS analysis of Filomena is presented in Table 1, with the standard values used for Hoba. The second and third columns contain, respectively, the mean and standard error of five line scans (each 15 μm wide and 250 μm long) across the Filomena sample. Also tabulated are the mean and standard deviation of four different INAA analyses, compiled in [2]. The laser ablation analyses agree with the INAA values within the quoted error, with the exception of Ru, which differs by 15%.

Bulk PGE concentrations have been determined for members of the large magmatic groups IIAB (Coahuila, Filomena, Mount Joy, Negrillos) and IIIAB (Cape York, Charcas, Costilla Peak, Grant, Henbury). Ru/Pt ratios of these samples are plotted in Figure 2; among these irons Ru/Pt ratios are remarkably consistent at 0.708 ± 0.035 , clustering near the chondritic value of 0.719 [4]. Comparable group IIAB and IIIAB INAA data, also shown in Figure 2, have a mean Ru/Pt ratio of 0.740 ± 0.093 [3]. Evidently Ru and Pt are not strongly fractionated from one another during

the fractional crystallization of metallic melts in iron meteorite parent bodies. Furthermore, the laser ablation ICP-MS method provides the accuracy and precision to identify this correlation more clearly than the neutron activation analyses.

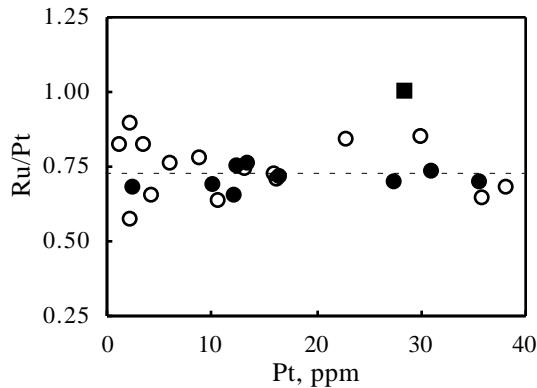


Figure 2. Ru/Pt ratios in iron meteorites. Filled circles: IIAB and IIIAB irons; square: Hoba IVB; open circles: Ref. 4; dashed line: chondritic value [4].

Figure 2 also shows that Hoba IVB does not obey the Ru-Pt relationship. Group IVB irons have been noted to have refractory siderophile enrichments relative to chondritic metal, implying condensation at higher temperature [5, 6]. The elevated Ru/Pt ratio in Hoba, depicted in Figure 2, supports this interpretation of the origin of group IVB irons.

A laser ablation ICP-MS line scan, across a taenite lamella in the Grant IIIB meteorite, is shown in Figure 3. The elemental abundances of Ru, Rh, and Pd in the kamacite phase are lower than those in taenite. Strong discontinuities in concentration denote the phase boundaries; the sharpness of the phase boundaries reflects the spatial resolution (40 μm in this case) of the technique, as well as the rapid uptake and washout times of the system. The M-shaped profile, characteristic of Ni distributions in taenite lamellae, is also apparent in these Ru, Rh, and Pd profiles.

Analyses of the taenite / kamacite distribution of PGEs were carried out on ten meteorites from groups IAB (Canyon Diablo, Odessa, Toluca), IIIAB (Cape York, Charcas, Costilla Peak, Grant, Henbury), and the pallasites (Glorieta Mountain, Imilac). To improve sensitivity, the M-profile data were collected as a series of line scans (30 μm wide, 150-300 μm long), each parallel to the taenite lamella and adjacent to the previous line scan. Distribution coefficients D_{vk} were calculated in each meteorite as ratios between the maximum concentration measured in the taenite phase and the average kamacite concentration for a particular element; their mean values and standard deviations are listed in Table 2. Previous attempts at measuring taenite / kamacite partitioning of PGEs have shown large discrepancies [7-9], but our results are broadly consistent with the limited data presented in [7]. The standard

deviations are generally small, indicating that the strength of PGE partitioning between taenite and kamacite does not vary greatly among iron meteorites. The light PGEs partition more strongly into the taenite phase than the heavy PGEs do; Au partitioning is also strong, and Re shows intermediate behavior.

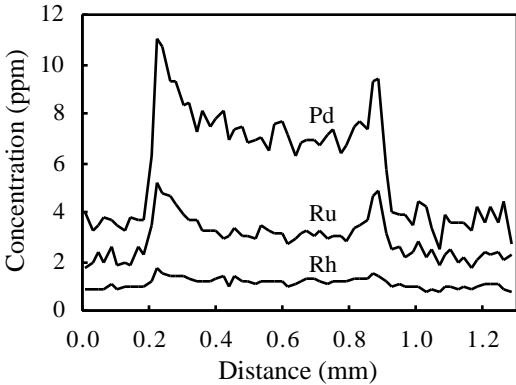


Figure 3. Profile across a taenite lamella in Grant [1].

Table 2. Taenite / kamacite partitioning data.

	Ru	Rh	Pd	Re	Os	Ir	Pt	Au
Mean D_{vk}	2.68	1.84	4.13	1.64	1.31	1.32	1.33	3.00
Std. Dev.	0.43	0.17	1.08	0.19	0.11	0.16	0.13	0.66
Ref. 7					2.5	1.7	1.5	2.8
Ref. 8	0.97	0.83	1.78	0.79	0.52	0.53	0.50	
Ref. 9				15.		4.3		19.

References: [1] Campbell A. and Humayun M. (1999) *Anal. Chem.*, in press. [2] Sylvester P. et al. (1993) *GCA*, 57, 3763-3784. [3] Pernicka E. and Wasson J. (1987) *GCA*, 51, 1717-1726. [4] Anders E. and Grevesse N. (1989) *GCA*, 53, 197-214. [5] Kelly W. and Larimer J. (1977) *GCA*, 41, 93-111. [6] Smoliar M. et al. (1996) *Science*, 271, 1099-1102. [7] Hsu W. et al. (1998) *LPSC*, XXIX, #1781. [8] Hirata T. and Nesbitt R. (1997) *EPSL*, 147, 11-24. [9] Rasmussen K. et al. (1988) *Meteoritics*, 23, 107-112.